REMARKS

Applicant has studied the Office Action dated December 28, 2001 and has made amendments to the claims. It is submitted that the application, as amended, is in condition for allowance. By virtue of this amendment, claims 1-4, 6-16, 25-27, and 32-36 are pending. Claims 5 and 28-31 have been canceled without prejudice. Claims 1, 7, 11, 12, 15, and 25-27 have been amended, and new claims 32-36 have been added. Reconsideration and allowance of the pending claims in view of the above amendments and the following remarks are respectfully requested.

The proposed drawing correction filed in Applicant's previous Amendment was approved by the Examiner. Applicant is now in the process of obtaining corrected formal drawings, and will forward them to the Examiner as soon as they are available.

Claims 1-16 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The claims have been amended to remove the language that was objected to by the Examiner, except for the language stating that the second additional layer is "substantially not doped" or "substantially lower" doped. It is respectfully submitted that the meaning of "a layer of polycrystalline silicon that is substantially not doped" would be clearly understood by one of ordinary skill in the art. Further, the specification does provide a standard for ascertaining the requisite degree with respect to such language. See, e.g., specification at 7:20-23. Applicant respectfully submits that all pending claims are now clear and definite. Therefore, it is respectfully submitted that the rejection of claims 1-16 under 35 U.S.C. § 112, second paragraph, should be withdrawn.

Claims 1-7, 10, 11, and 25-27 were rejected under 35 U.S.C. § 102(b) as being anticipated by Beinglass (U.S. Patent No. 5,141,892). Claim 8 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Beinglass in view of Alspector et al. (US Patent No.

4,441,249). Claims 9 and 14 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Beinglass in view of Alspector et al. and Wang et al. (U.S. Patent No. 5,646,061). Claims 12, 13, 15, and 16 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Beinglass. Claim 5 has been canceled so, with respect to this claim, these rejections are moot. With respect to claims 1-4, 6-16, and 25-27, these rejections are respectfully traversed.

The present invention is directed to in-situ deposition and doping methods for polycrystalline silicon layers that prevent the dopant from reaching the surface during a subsequent thermal treatment. One preferred embodiment of the present invention provides an in-situ deposition and doping method for a polycrystalline silicon layer of a semiconductor device. According to the method, a first intermediate layer of in-situ doped polycrystalline silicon is grown in a deposition chamber with a first thickness and a first doping level. After the first intermediate layer is grown, the deposition chamber is purged by stopping all gas flow into the chamber and pumping residual gas out of the chamber, so as to remove all available dopant.

After purging the deposition chamber, a second additional layer of polycrystalline silicon is grown with a second thickness and a second doping level that is lower than the first doping level. The first thickness is greater than the second thickness. Because the thinner second additional layer of polycrystalline silicon with a lower doping level is provided, the dopant is prevented from reaching the surface during a subsequent thermal treatment. Further, because the deposition chamber is purged between the growing of the first intermediate layer and the second additional layer, all of the dopant is removed before the less doped (or non-doped) second additional layer is grown and contamination is avoided.

The Beinglass reference discloses a process for depositing a highly doped polysilicon layer on a stepped surface so as to achieve enhanced step coverage. However, Beinglass does not disclose an in-situ deposition and doping method for a polycrystalline silicon layer in which a first intermediate layer of in-situ doped polycrystalline silicon is grown in a deposition chamber with a first thickness and a first doping level, <u>then the deposition chamber is purged by stopping all gas flow into the chamber and pumping residual gas out of the chamber, and then</u> a second additional layer of polycrystalline silicon is grown with a lower second thickness and a lower

second doping level, as is recited in amended claim 1. Amended claim 15 contains similar recitations.

Similarly, Beinglass does not disclose an in-situ deposition and doping method for a polycrystalline silicon layer in which a first intermediate layer of in-situ doped polycrystalline silicon is grown with a first thickness and a first doping level, and a second additional layer of polycrystalline silicon is grown with a second thickness and a second doping level that is lower than the first doping level, <u>with the first thickness being at least about 8 times greater than the second thickness</u>, as is recited in amended claim 25.

The Beinglass reference discloses a process for depositing a doped polysilicon layer by depositing a series of thin polysilicon layers that are alternately doped and non-doped. A thermal annealing step is then performed to distribute the dopant in the doped layers throughout all of the polysilicon layers in a uniform, homogeneous way. In the process of Beinglass, deposition of the doped polysilicon layer is carried out by flowing a source of silicon, a source of dopant, and an optional carrier gas into a deposition chamber. Then, "the flow of the dopant source is shut off, while the source of silicon continues to flow into the deposition chamber" to deposit the non-doped polysilicon layer. Beinglass at 4:17-22. After deposition of the non-doped polysilicon layer is complēted, "the flow of dopant is again started" to deposit another doped polysilicon layer, and this is repeated until the desired thickness of polysilicon has been deposited. <u>Id.</u> at 4:22-37. Thus, Beinglass discloses depositing a non-doped polysilicon layer on a doped polysilicon layer by simply shutting off the flow of the dopant source gas while the silicon source gas continues to flow into the deposition chamber.

In contrast, in the embodiments of the present invention recited in amended claims 1 and 15, the deposition chamber is purged (by stopping all gas flow into the chamber and pumping residual gas out of the chamber) after the first intermediate layer is grown. Only after the deposition chamber has been purged to remove all available dopant is the second additional layer of polycrystalline silicon grown. Such purging of the deposition chamber between the growing of the first intermediate layer and the second additional layer is necessary to prevent contamination of the second additional layer of polycrystalline silicon. Beinglass does not teach or suggest an in-situ deposition and doping method for a polycrystalline silicon layer in which the

deposition chamber is purged after the first intermediate layer is grown so as to remove all available dopant, and then a second additional layer of polycrystalline silicon is grown after the purging of the deposition chamber.

Further, in the process of Beinglass, both doped polysilicon layers and non-doped polysilicon layers are repeatedly deposited to a thickness of between 400 and 800 Angstroms so as to sum to a total thickness of between 1500 and 4000 Angstroms. Beinglass never teaches or suggests performing the deposition such that a doped polysilicon layer is thicker than a non-doped polysilicon layer. With the disclosed thickness range of between 400 and 800 Angstroms for each of the doped and non-doped polysilicon layers, the most that is disclosed is a non-doped polysilicon layer of having a thickness of 400 Angstroms overlying a doped polysilicon layer having a thickness of 800 Angstroms. Thus, at most, Beinglass discloses that the thickness of the doped polysilicon layer is 2 times greater than the thickness of the non-doped polysilicon layer.

In contrast, in the embodiment of the present invention recited in amended claim 25, a less doped (or non-doped) polysilicon layer is grown over a doped polysilicon layer, with the thickness of the doped polysilicon layer being at least about 8 times greater than the thickness of the non-doped polysilicon layer. Because of these relative thicknesses, the average doping level of the doped polysilicon layer is not significantly changed by diffusion of the dopant to the less doped (or non-doped) layer in any subsequent thermal treatment. This allows the dopant to be prevented from reaching the surface during a subsequent thermal treatment, without significantly changing the average doping level in the thermal treatment.

Beinglass does not teach or suggest depositing polysilicon layers such that a doped polysilicon layer is at least about 8 times thicker than a less doped (or non-doped) polysilicon layer. In fact, Figures 4-7 of Beinglass disclose depositing doped polysilicon layers that are thinner than non-doped polysilicon layers. Furthermore, Beinglass is directed to producing a doped polysilicon layer that has better step coverage, and achieves this by alternately depositing doped and non-doped polysilicon layers. As explained in Beinglass, this produces better step coverage because the non-doped polysilicon layers are deposited more uniformly so as to more quickly fill low areas such as trenches. In other words, the non-doped layers act to fill low areas that would be filled much slower by the deposition of a doped layer. Thus, in the process of

Beinglass, if the non-doped polysilicon layer was made substantially thinner than the doped polysilicon layer (as in the present invention), the process would not be able to achieve the better step coverage that is desired. Accordingly, it is submitted that Beinglass actually teaches away from growing a doped polysilicon layer that is substantially thicker than a less doped (or non-doped) polysilicon layer.

Applicant believes that the differences between the Beinglass and the present invention are clear in amended claims 1, 15, and 25, which set forth in-situ deposition and doping methods according to various embodiments of the present invention. Therefore, claims 1, 15, and 25 distinguish over the Beinglass reference, and the rejections of these claims under 35 U.S.C. § 102(b) and 35 U.S.C. § 103(a) should be withdrawn.

As discussed above, claims 1, 15, and 25 distinguish over the Beinglass reference. Furthermore, the claimed features of the present invention are not realized even if the teachings of Alspector and Wang are incorporated into Beinglass.[1] Neither Alspector nor Wang teaches or suggests the claimed features of the present invention that are absent from Beinglass. Thus, claims 1, 15, and 25 distinguish over the Beinglass, Alspector, and Wang references, and thus, claims 2-4, 6-14, and 27, claim 16, and claim 26 (which depend from claims 1, 15, and 25, respectively) also distinguish over the Beinglass, Alspector, and Wang references. Therefore, it is respectfully submitted that the rejections of claims 1-4, 6-16, and 25-27 under 35 U.S.C. § 102(b) and 35 U.S.C. § 103(a) should be withdrawn.

Claims 32-36 have been added by this amendment, and are provided to further define the invention disclosed in the specification. Claims 32-36 are allowable for at least the reasons set forth above with respect to claims 1-4, 6-16, and 25-27. Additionally, Applicant submits that Beinglass does not disclose growing a first polysilicon layer with a first thickness and a first doping level, growing a second polysilicon layer with a second thickness and a lower second doping level, and performing a subsequent thermal treatment, with the first thickness being

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[1] Applicant makes no statement as to whether such a combination is even proper.

greater than the second thickness such that the average doping level of the first polysilicon layer after the thermal treatment is at least about 1×10^{19} atoms/cm^3.

Further, it is submitted that such a resulting dopant level is supported by the specification. In particular, the specification states that a doped polysilicon layer has a doping level of 1×10^{20} atoms/cm^3 and that in one embodiment the second additional polysilicon layer has a substantially lower dopant level of 1×10^{17} atoms/cm^3. The specification also states that in a preferred embodiment a 10:1 ratio is maintained between the thicknesses of the doped polysilicon layer and the second additional polysilicon layer. With such dopant levels and thicknesses for the two polysilicon layers, the performance of a subsequent thermal treatment to diffuse the dopant results in an average doping level of the first polysilicon layer of about 1×10^{19} atoms/cm^3. Beinglass does not teach or suggest depositing a doped polysilicon layer and a less doped polysilicon layer with thicknesses and doping levels such that after a thermal treatment the average doping level of the doped polysilicon layer is at least 1×10^{19} atoms/cm^3.

In view of the foregoing, it is respectfully submitted that the application and the claims are in condition for allowance. Reexamination and reconsideration of the application, as amended, are requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is invited to call the undersigned attorney at (561) 989-9811 should the Examiner believe a telephone interview would advance the prosecution of the application.

Respectfully submitted,

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By: ____________________

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APPENDIX

IN THE CLAIMS:

1. (Twice Amended) An in-situ deposition and doping method for a polycrystalline silicon layer of a semiconductor device, said method comprising the steps of:

growing, in a deposition chamber, a first intermediate layer of in-situ doped polycrystalline silicon with a first thickness and a first doping level;

after growing the first intermediate layer, purging the deposition chamber by stopping all gas flow into the chamber and pumping residual gas out of the chamber, so as to remove all available dopant; and

after purging the deposition chamber, growing a second additional layer of polycrystalline silicon with a second thickness and a second doping level that is lower than the first doping level,

wherein the first thickness is [substantially] greater than the second thickness [so that the average doping level resulting from a summation of the first intermediate layer and the second additional layer is not significantly changed by diffusion of doping atoms from the first intermediate layer to the second additional layer].

7. (Twice Amended) The in-situ deposition and doping method as defined in claim 1, further comprising the step of:

performing a subsequent thermal treatment to diffuse dopant from the first intermediate layer to the second additional layer,

wherein the average doping level [resulting from the summation] of the first intermediate layer [and the second additional layer is not significantly changed by] after the thermal treatment is at least about 1×10^{19} atoms/cm^3.

11. (Twice Amended) The in-situ deposition and doping method as defined in claim 10, further comprising the step of:

performing a subsequent thermal treatment to diffuse dopant from the first intermediate layer to the second additional layer,

wherein the average doping level [resulting from the summation] of the first intermediate layer [and the second additional layer is not significantly changed by] after the thermal treatment is at least about 1×10^{19} atoms/cm^3.

12. (Twice Amended) The in-situ deposition and doping method as defined in claim 10, further comprising the step of:

performing a subsequent re-oxidation treatment to diffuse dopant from the first intermediate layer to the second additional layer,

wherein the average doping level [resulting from the summation] of the first intermediate layer [and the second additional layer is not significantly changed by] after the re-oxidation treatment is at least about 1×10^{19} atoms/cm^3.

15. (Twice Amended) An in-situ deposition and doping method for a polycrystalline silicon layer of a semiconductor device, said method comprising the steps of:

growing, in a deposition chamber, a first intermediate layer of in-situ doped polycrystalline silicon with a first thickness and a first doping level;

after growing the first intermediate layer, purging the deposition chamber by stopping all gas flow into the chamber and pumping residual gas out of the chamber, so as to remove all available dopant;

after purging the deposition chamber, growing a second additional layer of polycrystalline silicon with a second thickness; and

performing a re-oxidation thermal treatment to diffuse dopant from the first intermediate layer to the second additional layer,

wherein the second additional layer is substantially not doped, and

the first thickness is [substantially] greater than the second thickness [so that the average doping level resulting from a summation of the first intermediate layer and the second additional layer is not significantly changed by diffusion of dopant from the first intermediate layer to the second additional layer in the re-oxidation thermal treatment].

25. (Amended) [The] An in-situ deposition and doping method [as defined in claim 1,] for a polycrystalline silicon layer of a semiconductor device, said method comprising the steps of:

growing a first intermediate layer of in-situ doped polycrystalline silicon with a first thickness and a first doping level; and

growing a second additional layer of polycrystalline silicon with a second thickness and a second doping level that is lower than the first doping level,

wherein the first thickness is at least about 8 times greater than the second thickness.

26. (Amended) The in-situ deposition and doping method as defined in claim [1] 25, wherein the first thickness is at least about 10 times greater than the second thickness.

27. (Amended) The in-situ deposition and doping method as defined in claim 1, wherein the polycrystalline silicon layer of the semiconductor device consists of only the first intermediate layer and the [substantially] overlying thinner second additional layer that provides a barrier during [a re-oxidation] any subsequent thermal treatment.